



High Capacity
Optoelectronic
Interconnects

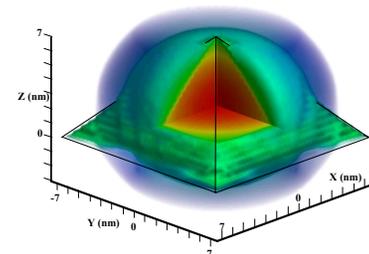
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QUANTUM DOT RESEARCH

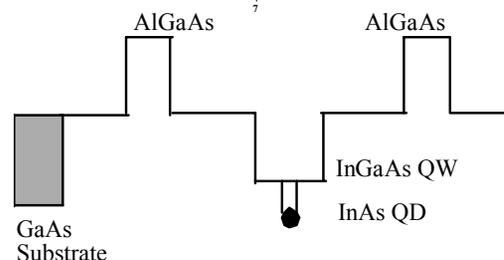
Theory

QD electron ground state wavefunction for a pyramidal type dot.



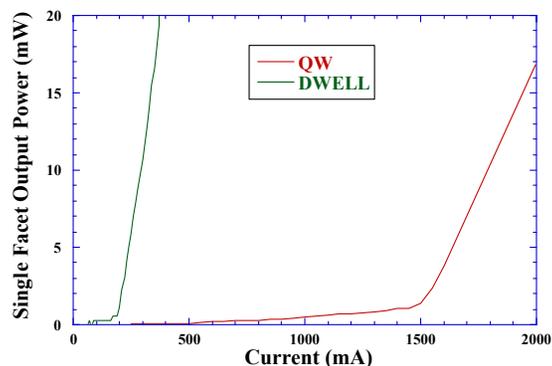
Architecture

QD Lasers grown by MBE
Energy diagram of the layers in a QD "dots-in-a-well" laser.

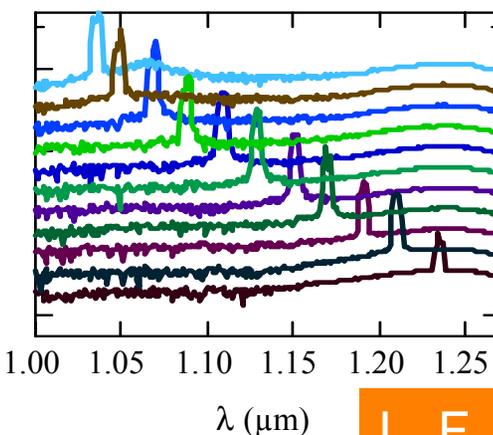


Laser Properties

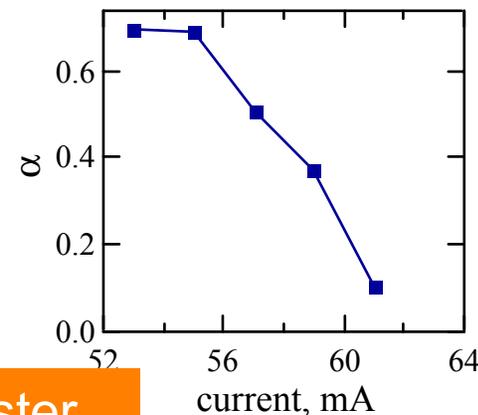
J_{th} 7x lower than comparable 1.24 μm QW lasers.



201-nm tunable range in an external cavity.



Record low linewidth enhancement factor



L. F. Lester,
K. Malloy



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The recent progresses in quantum dot lasers have all been associated with surrounding the InAs dots with InGaAs layers.

- **Grow InAs dots on an InGaAs buffer (UT Austin)**
- **Cover InAs dots by an InGaAs layer (NEC, Ioffe, Fujitsu)**
- **Grow InAs dots on an InGaAs layer, and then cover the InAs dots by an InGaAs layer (UNM)**

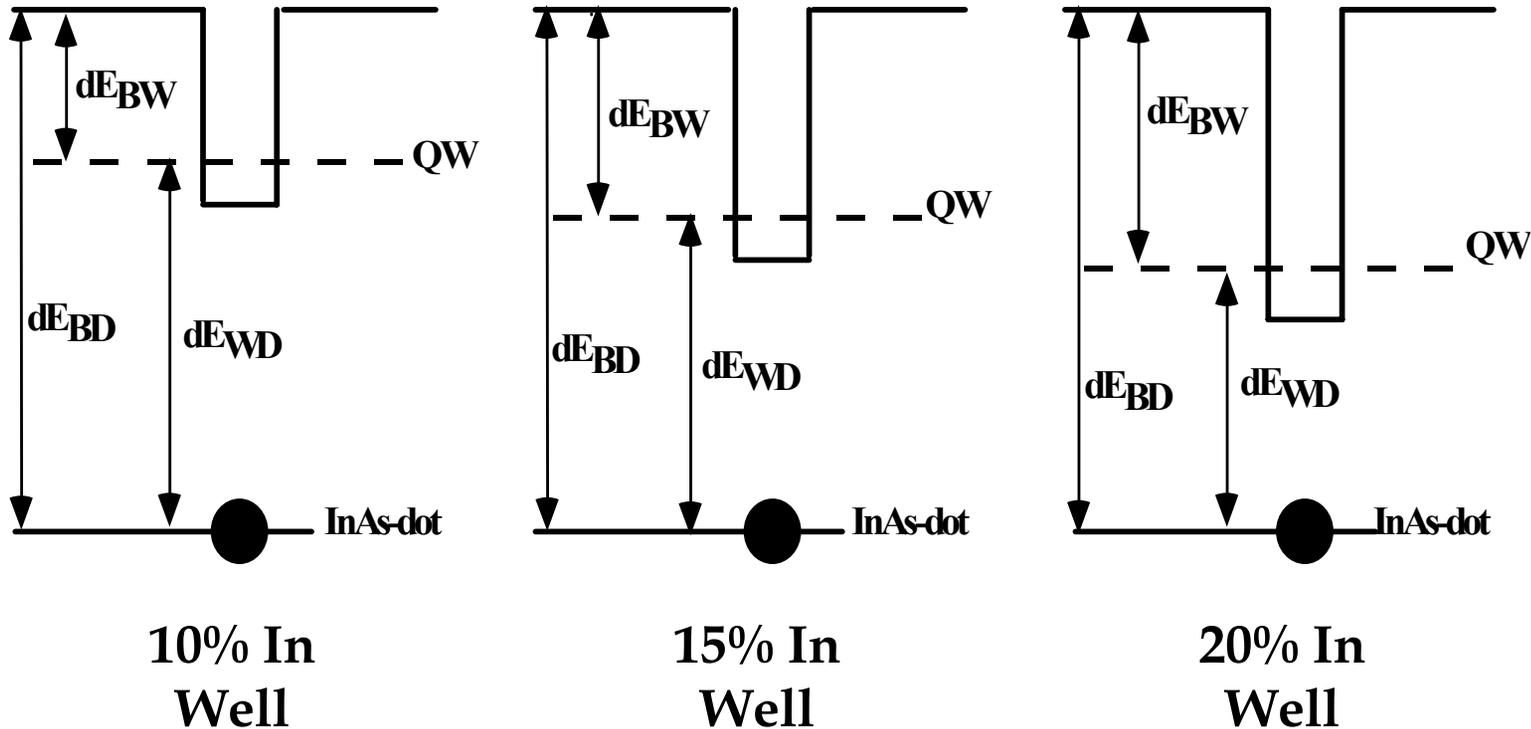
Benefits: Longer wavelength, higher dot density

Goal:

Explore the role played by this InGaAs layer in the quantum dot laser performance



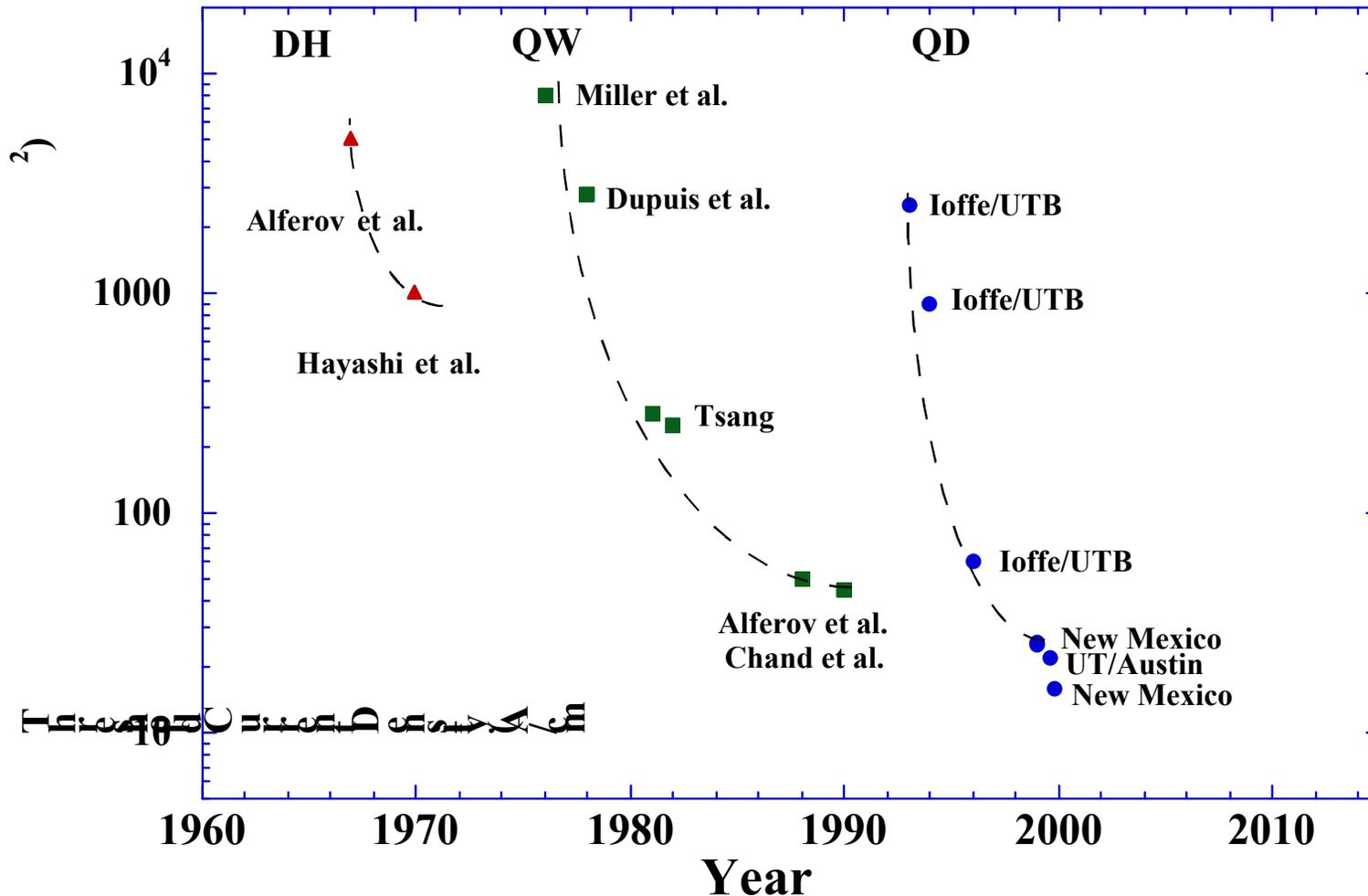
“Dots-in-a-Well” (DWELL) Structures with Different QWs



	Injection Efficiency
10 % In QW	30%
15 % In QW	38%
20 % In QW	55%



Semiconductor Laser Threshold Current Density Reduction Vs. Time



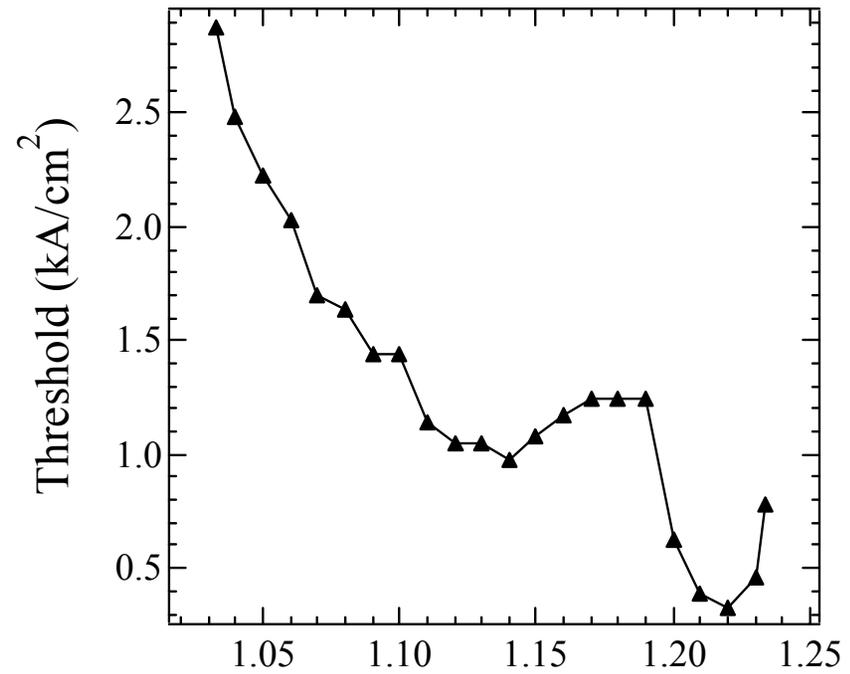
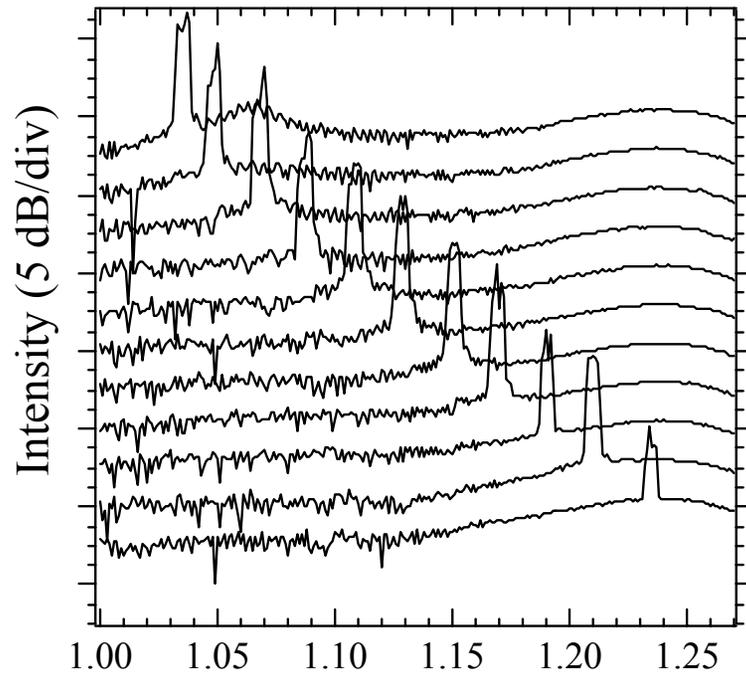
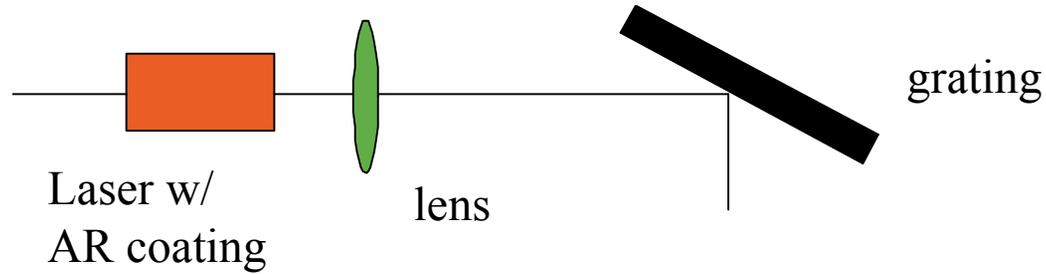


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External Cavity Tuned QD Lasers



Tuning Wavelength, λ (μm)



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Summary of QD Laser Tuning Experiments

- **Wavelength tuning comparison**
 - DWELL-1: tuning range = 183 nm, max bias: 2.22 kA/cm², L = 2.0 mm
 - DWELL-2: tuning range = 201 nm, max bias: 2.87 kA/cm², L = 1.7 mm
 - MQW: tuning range = 240 nm, bias: 33 kA/cm²
- **Advantages of QD lasers for tuning applications**
 - *Inhomogeneous broadening* results in broad gain spectrum.
 - *Low density of states* results in low J_{th} and carrier population of higher-energy states at low pump current.
 - *Homogeneous gain broadening* enables sufficient gain to occur at the selected frequency along with suppression of free-run lasing.
 - *Achieve broad-band tuning at low bias.*
- **Work in progress**
 - Investigate lasing and tunability from 1.45 to 1.65 μ m.
 - Optimize tuning characteristics: broader size distribution, improved AR coatings



1.22 μm InAs QD Laser Spectrum

$$\alpha(N, \omega) = \frac{\partial \chi' / \partial N}{\partial \chi'' / \partial N} = -\frac{2\omega \partial(\delta n) / \partial N}{c \partial g / \partial N} = -\frac{4\pi \partial n / \partial N}{\lambda \partial g / \partial N}$$

- Hakki-Paoli measurement on a 1.5 mm x 30 micron QD laser at different bias levels

- Symmetric gain profile results in extremely small linewidth enhancement factor, $\alpha = 0.1$

- Chirp-free modulation!
- Narrow linewidth DFB

